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TECHNICAL INTEGRATIONS AND SPECIAL REPRESENTATIONS FOR A VERY LARGE SCALE CARTOGRAPHY ON ANCIENT CITIES APPLIED TO THE SURVEY OF THE MAIN SQUARE AT MONTAGNANA, Padova (Italy)

Summary

The preparation of a whole set of maps at 1:200 scale of a sample area at Montagnana historic site, has arisen new interests in the classical cartography. Integration of different technical procedures, map and prospect representation, codification of metric and qualitative information have been discussed.

In a previous paper /1/ after the explanation of the "provocative" character of this study, a series of problems have been analised, justifying the choice of the 1:200 scale as an experimental basis. A sample area at Montagnana, an ancient village covering 30 hectares approx., on which since two years some hundred terrestrial shots have been performed, was therefore chosen, and then the making of a 1:200 scale cartographic system was decided, providing the division of the whole historic area into an orthogonal network with 100 x 100 m^2 meshes, originating and oriented according to the national reference system. In case of employment of the said system to all the historic Italian sites, a geographic reference frame connecting the different surveyed areas will be realized. Such a procedure requires:

a - the possibility of drawing partial maps of the zones physically non-connected one another, but geographically fully enclosed;

b - the substantially indifference of the maps to the geoid or tangent plane reduction procedures;

c - the practical insertion into the official cartographic system of the national territory;

d - the making of a basic informative tool useful and available in memorizing procedures and to be utilized as a reference in practical use;

e - the availability of a complex informative system which being founded on coordinate numerical recording, allows the spatial localization of different information aiming at data automatic processings. This particular practical use of the maps seems to be especially helpful in historic and artistic monument catalogation and in the data-bank making.

The sample area was established in the main square at Montagnana, as it is rich in architectural elements both of building units and urban facilities, the first ones nearly completely surveyable by aerial and terrestrial shots, the second ones by aerial shots; the whole then integrated, as for the non-visible elements, by terrestrial surveys. Accuracy was especially aimed at, taking into account the map-scale.

Flight. - During Spring 1979 three parallel strips were carried out covering completely the ancient center of Montagnana. A single-motor aircraft was employed on which a 300 mm Zeiss camera was mounted, 1/1000 stop, overlap 60% approx.; flight height 300 m approx. Photograms resulted therefore at a scale ranging from 1:900 to 1:1000. Dragging effects were negligible. Printing of positives on 0.18 mm films.

Ground control points for aerial and terrestrial restitution of photographs. - The network consists of a precision polygonal closed around the village, slightly larger than 2 km, with two transversal branches along the main street axes and perpendicular one another. The network planimetric adjustment gave a m.s.e. on each vertex not exceeding ± 20 mm. The network is framed into the national reference system (Gauss-Boaga) with 1 vertex and 1 azimuth without distance cartographic reductions. All the vertexes are materialized in fix landmarks: planimetric coordinates of photographic control points were determined by irradiation starting from the said landmarks for aerial photograms, and plano-altimetric coordinates, when necessary, of points signalized on façades for terrestrial photograms.

Heights of ground points were determined by geometric levelling. Accuracy of control points is of the same order as that of the frame's vertexes. The three successive aerial photograms included the whole studied area. The two resulting models are based on 15 uniformly distributed points and determined in their three coordinates.

Terrestrial shots. - Bi-cameras (SMK 120) were mainly employed; for few shots only a monocamera (Wild P31), 100 mm focal length was used. They were always with horizontal axis, after positioning of the camera on the ground or on the top of an especially equipped car, owing to the low height of buildings facing the streets. Orientation and dimensioning of photograms taken by the bi-camera were carried out not only by the usual operative technique, namely positioning a rod at the building, but also assuming some photographic points of façades as having the same coordinates obtained by aerial shot restitution.

The expediency of such a procedure was checked on some buildings by absolute orientation of the model on some points marked on the façade and determined by the control topographic network and then by restitution of terrestrial model of points common to the aerial model and comparison with their absolute coordinates. The numerical results of residuals which are satisfactory for now, do not allow a meaningful statistical interpretation owing to the sample's smallness. A well-grounded belief is however admitted that as for 1:200 scale mapping, the method is quite effective.

Aerial shot restitution. - The instrument used was an OMI AP/C31, an analytical instrument that OMI itself put kindly at our disposal and whose performance in this very field will undergo a further improvement as the AP/C 4 model is near to be produced. Restitution was consequently done partly at OMI, Rome and partly in the Istituto di Topografia, Fotogrammetria e Geofisica del Politecnico, Milan,where the instrument was successively planted. Some starting inconveniences due to usual checking problems were overcome but they unavoidably influenced the foreseen working program. The particular software characteristics of the instrument too required some fitting and operative devices. The use of an analytical instrument was whosen as more versatile and suited to the aim. The possibility of introducing focal lengths of aerial as well as terrestrial shots even if different as in the case of the bi-cameras, the point numerical restitution speedness and its accuracy make it the ideal instrument when continuous passage is required from aerial to terrestrial shots and viceversa.

The model absolute orientation is possible on AP/C 31 by means of a maximum of 12 known points. This procedure was followed for our two models, with 8 ground points in all for the first and 7 for the second one: 1 and 2 ground points respectively were neglected due to their unsure position or poor visibility. Table I reports the absolute orientation residuals of the two restituted models.

TABLE I

Points	Model 1 residuals (cm)			Model 2 residuals (cm)		
	x	y	z	x	y	z
1	0.0	0.6	0.9	-1.8	0.3	-0.3
2	0.0	0.0	-2.5	-3.0	0.0	5.5
3	4.2	0.6	-3.3	0.0	0.0	0.1
4	-7.9	-7.4	2.7	3.6	0.7	-7.1
5	4.2	0.9	6.8	-2.4	0.1	0.2
6	3.6	2.7	0.4	-4.8	4.4	3.8
7	-5.4	-4.2	-2.9	1.2	-5.9	-2.2
8	-1.2	6.4	-2.2			

The orientation's angular parameters never exceed 2^g. Graphic restitution, including a little smaller than 3 hectares ares, has considered the aims of the map itself, which may be summarized, taking into account the reasons explained in /1/, on the two planimetries on which the programmed cartographic maps are based; they form the two roof-height and ground maps and give graphic information on all the most meaningful and possible elements of this scale. The drawing is completed by numerical, literal and symbolic marks explained in the legenda, aiming also at underlining its technical and instrumentalvalue, avoiding its weighing with over direct-information and graphic descriptions. A suitable numerical codification allows to find on the map-margin the respective absolute coordinates for the points of geometrical interest in the planimetries (edges, building caissons, eaves, etc.) what requires the coded recording of all the restituted points among which the essential and meaningful ones are chosen, still being however all available. The map or the two cartographic drawings are partitioned into 0.5 x 0.5 m^2 squares according to the official network so as the everytime represented area be 1 hectare. A 20 mm "dumb" out-framing eases the connection of contiguous squares. This map completed with significant numerical information turns out to be in our opinion easily readable, and allows the spatial framing of building reliefs at a detailed scale. Fig.1,2,3 represent the said drawings.

Restitution accuracy tests. - The tests were made in two times: the first is a repetition of the analytical restitution, the second is a direct ground control. As for the first one, a re-orientation of the first model was made. Table II shows the residuals of the control points of the repeated Model 1. The control points of the previous operation have been used.

TABLE II

Points	Model 1 (repeated) residuals (cm)		
	x	y	z
1	0.6	2.0	1.1
2	-4.8	-4.4	-3.5
3	5.4	-1.5	-3.1
4	0.0	0.0	3.7
5	0.0	0.0	4.9
6	0.6	2.8	5.1
7	-3.0	0.9	-5.3
8	0.0	0.0	-2.9

Orientation parameters are practically the same as in the first test. The restitution was then repeated for a qualitatively selected series of points. The certainly and clearly individuated ground points as edges of traffic signals, manholes, etc., were separately considered from the as well sure ones but more difficult to be collimated due to their nature as f.i. the bases of buildings, of arcades, etc.; the same was made for non-exactly identified points generally on height as balconies, eaves, chimney-tops, etc. The results are summarized on Table III.

As one can see, the kind of the point influences somehow the restitution accuracy; well individuated ground points even if numerically few, show lower m.s.e.

Averaged values show some systematical differences in coordinate y, due to a different positioning of the model in the second restitution as to the first one. It must be stressed that

TABLE III

Kind of point	Coordinates	N^of points with distance Δ from 2^and 1^restitution comprised between cm				Total of points	Average cm	m.s.e. cm
		$0 \leq \Delta < 5$	$5 \leq \Delta < 8$	$8 \leq \Delta < 12$	> 12			
Eaves edges, roof-tops, sky lights, chimney-tops, balconies, etc.	x	82	7	4	1		0.4	3.5
	y	41	47	5	1	94	-3.8	5.2
	z	78	11	5	0		1.9	3.7
Groud points like bases of buildings, pillars, etc.	x	55	8	1	3		0.7	4.7
	y	30	22	7	8	67	-5.9	7.8
	z	48	16	3	0		3.1	4.2
Ground points like manholes, pedestrian crossings,etc.	x	17	7	2	0		3.9	4.5
	y	17	8	1	0	26	-2.5	3.7
	z	24	2	0	0		0.0	2.6

the 13 values higher than 12 cm are really little exceeding such value: the max values is 18 cm. The comparison between absolute coordinates of ground points fixed by topographic method and the restituted coordinates of the same points ensures that the differences are of the same order as between the two different restitutions. The values found may be improved by taking into account the experience, but they are altogether significant on the real possibilities to realize 1:200 scale maps.

Graphic drawings to be mapped at 1:200 constitute as said /1/ an integrated whole of maps and prospects bearing defined functions and meaning. One of the general aims of this complex of representations is to supply a unifying spatial reference frame to act as a model for all the detailed scale surveys which, like 1:200 respect to lower scales, may be positioned and oriented within the mesh of 1 hectare still keeping the intrinsic accuracy characteristics typical of different scales. Such a system allows practically expectations for a real co-ordination of all types of cartographic production also for highly detailed scales and according to the systems of projection most fitted for survey operations and drawing purposes.

Cataloguing problems of historic and artistic monuments would thus probably find more practical and resolutive answers.

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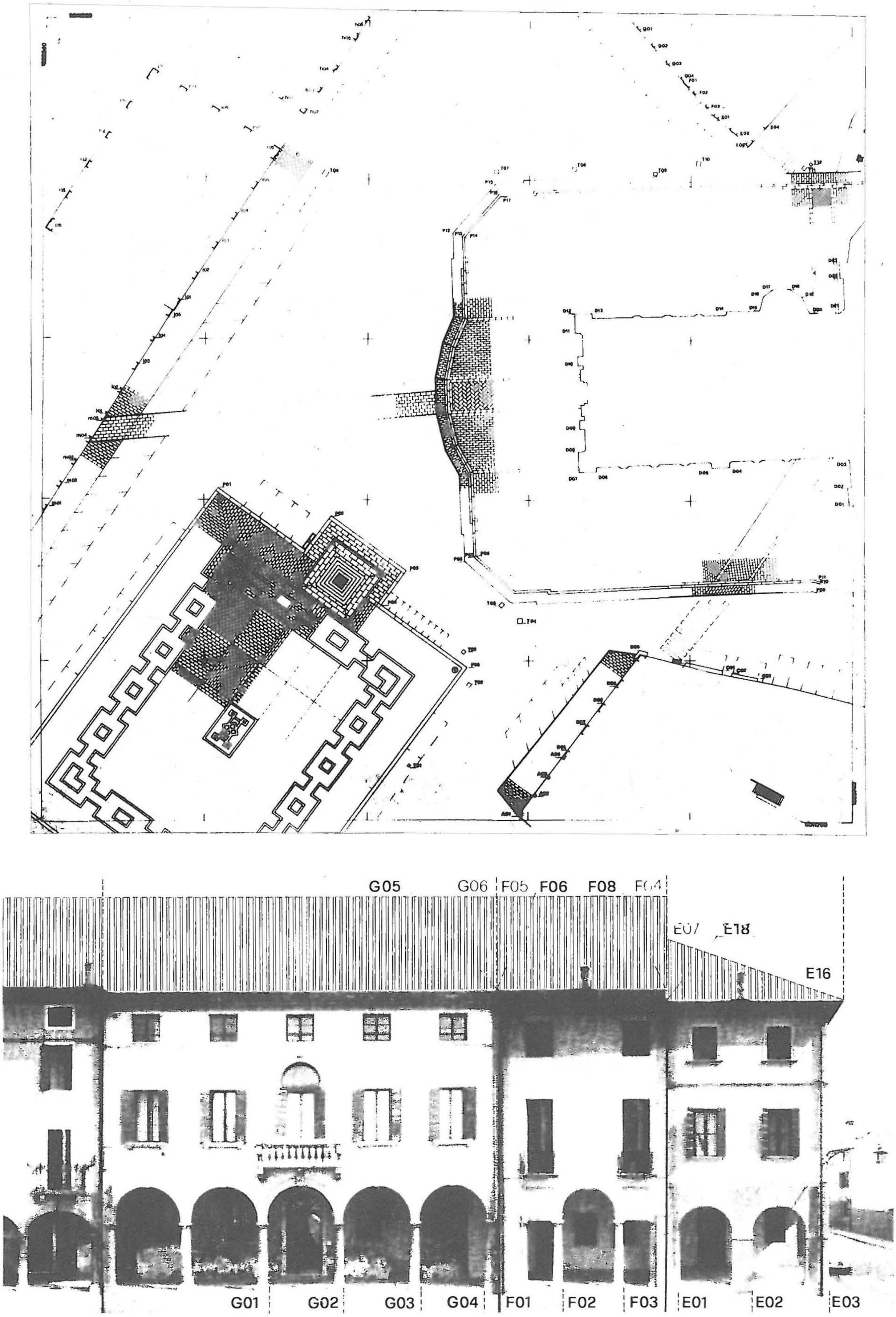
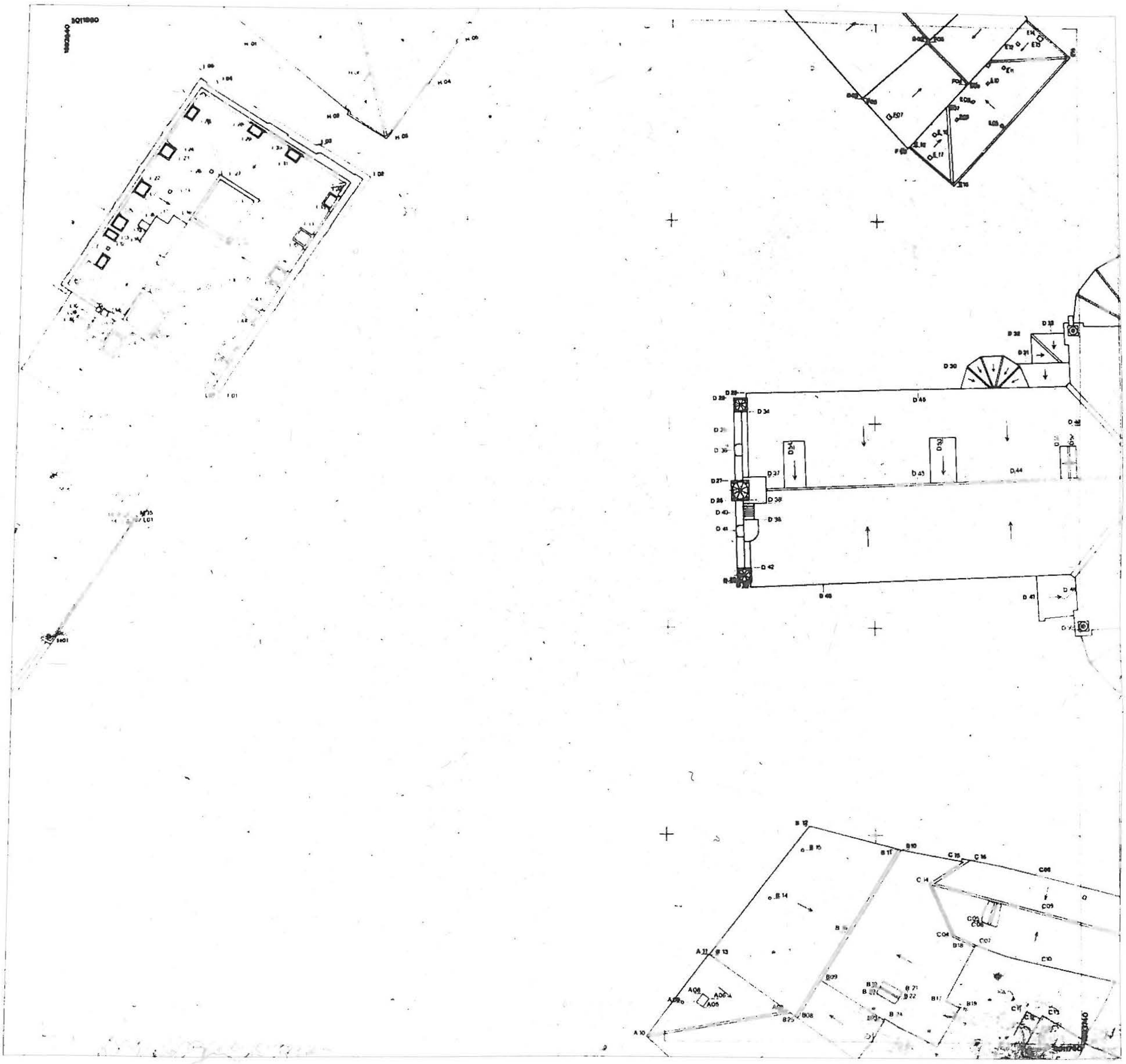


Fig.1 - Above: ground map in the network mesh
Below: adjustment mosaic of building prospects



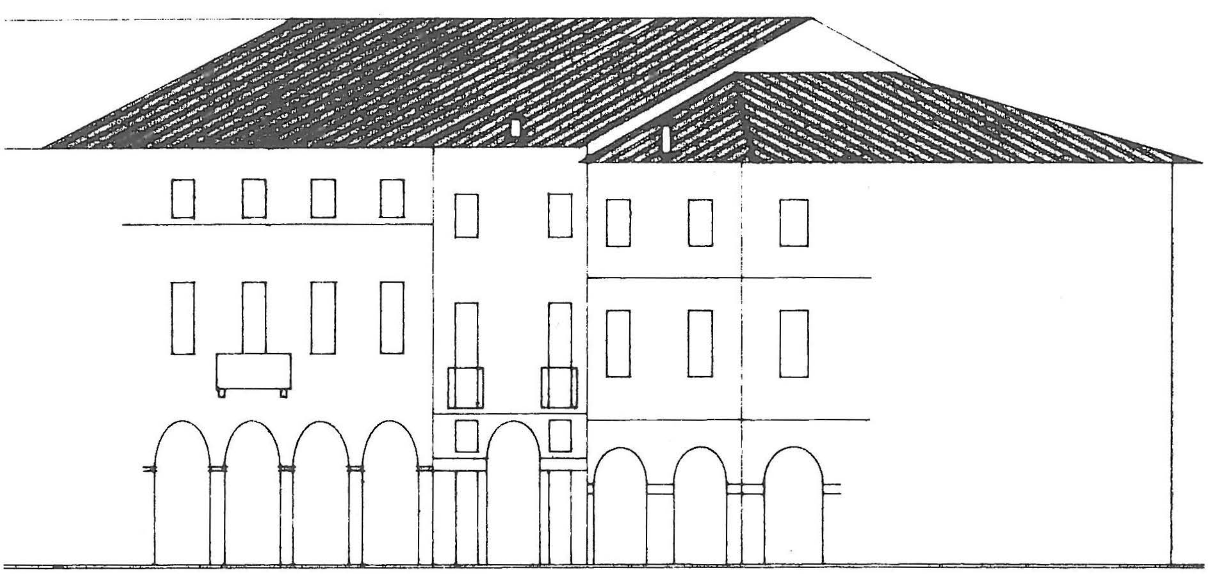


Fig.2 - Above: 1:200 roof map (detail in the network mesh)
Below: making-up of the prospect geometric schema according to a network axis

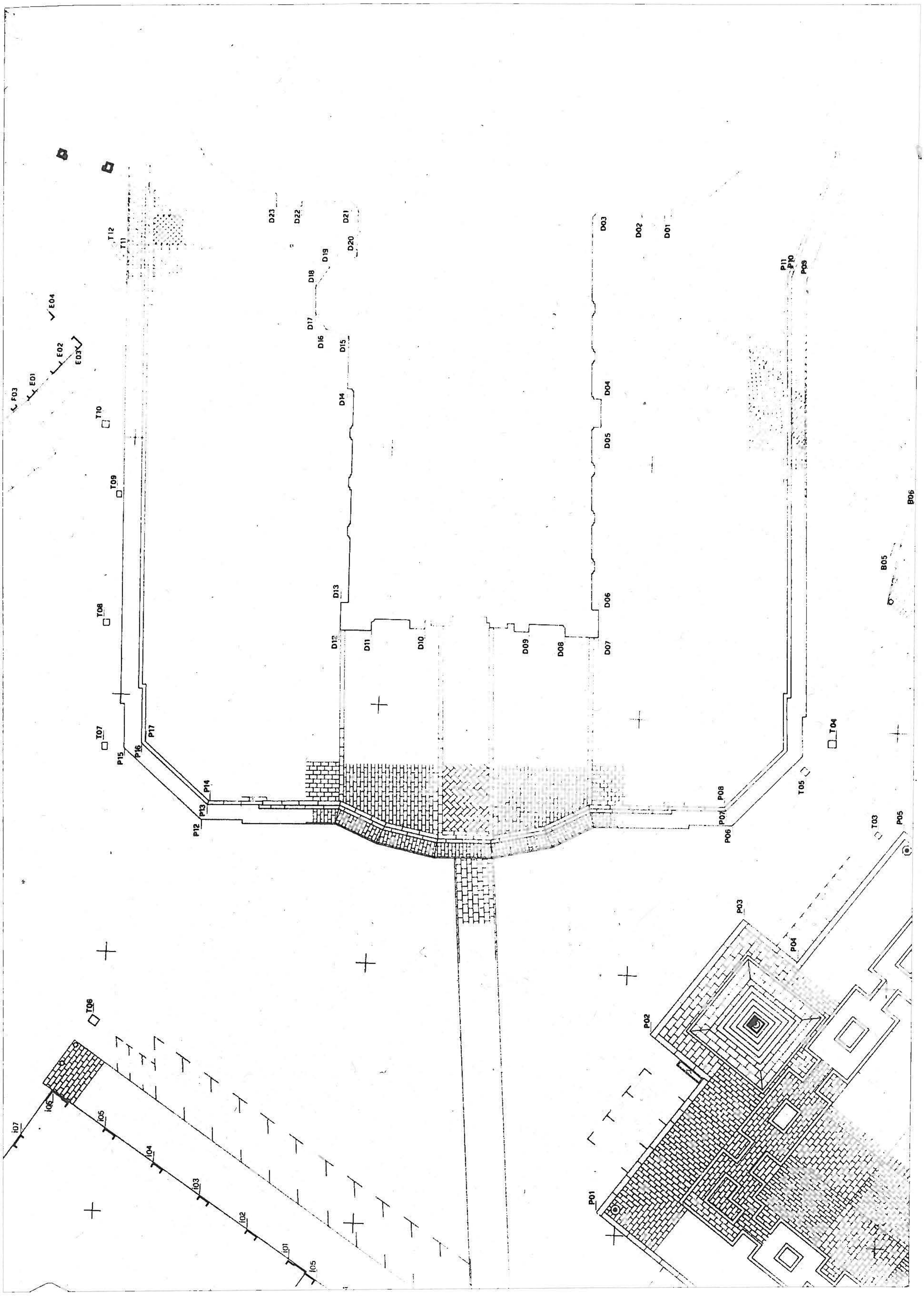


Fig.3 - Ground map showing the location of network mesh